REMARKS

In the Office action of April 14, 2009, claims 15, 17-23, 25-30 were rejected under 35 U.S.C.102 (e) as being anticipated by Wang et al. (U.S. PG Pub No. 2008/0163688A1).

In addition, in the Office action of April 14, 2009, claims 16 and 24 were rejected under 35 U.S.C.103 (a) as being unpatentable over Wang et al. in view of Kuroda et al. (U.S. Patent No. 6,408,123 B1).

In response to the Examiner's rejection, Applicant has amended the claims for a better understanding and Applicant hereby submit the following remarks for the purposes of explaining the differences between the cited references and the present invention as claimed herein.

The cited references include the following:

U.S. PG Pub No. 2008/0163688A1 (Wang et al.)

U.S. Pat. No. 6,408,123B1 (Kuroda et al.)

Wang, et al. discloses that, in relation to the embodiments of Fig. 1A to Fig 1C:

"The electrodes (2, 3) and quartz substrate 1 enable QCM sensing to be performed. As shown in the FIG. 1C, the opening 32 (or "window") at the center of electrode 3 enables SPR analysis to be conducted by allowing a beam of incident light to pass through the quartz substrate 1 so that, at a particular incident angle, the light beam undergoes total internal reflection to excite surface plasmon resonance (SPR) at the surface of the sensing electrode 2." (See Wang, et al., paragraph 0088.)

Wang et al. also refers to the employment of "surface acoustic wave" sensing instead of "quartz crystal microbalance" sensing (see Wang et al., paragraph 0058).

Therefore, it is conceded that Wang et al. discloses a sensor element and method for detecting an adsorbed mass of a substance using a piezoelectric element. It is further conceded that Wang et al. can observe the

optical characteristics of the adsorbed substance and the detection thin film after adsorption of the substance from a change in outgoing light caused by adsorption of the substance.

According to the sensor element and the detection method disclosed by Wang et al., the ATR coupler for exciting the surface plasmons (see Wang paragraph 0013, specifically its "prism") is designed to be attached to the oscillated plane of the piezoelectric element.

For this reason, Wang et al. proposes that the air gap between the ATR coupler and the piezoelectric element may be filled and sealed with the index matching medium (see Wang et al., e.g. paragraph 0024) by various methods. This medium is usually liquid, but when it has an increased viscosity, then it has the drawback that Q-value in QCM lowers (see Wang et al., paragraph 0123).

It should be noted that according to the present invention, no ATR coupler is necessary, though Wang et al. needs one.

The prism 8 shown in Fig. 1 and 2 of the present invention is used as an inputting/outputting means inputting/outputting light to the waveguide path and provided on both ends of QCM substrate, and hence, the prisms have no influence on the oscillation which is utilized for performing QCM.

Further, according to the present invention, the prism 8 as shown in Fig.1 and 2 is not necessarily required, and, in an alternative form of the invention, an optical fiber may be brought close to the end face of the waveguide to input/output the light (e.g. butt-coupling method, Applied Optics, 16(4), page 1026-1032, copy being attached). Accordingly, the present invention provides a solution to the problem inherent to the method of Wang et al. wherein the Q-value in QCM drops by using the index matching medium. Besides, it is also to be noted that according to the method of Wang et al., the QCM electrode adjacent to the ATM coupler is ring-shaped due to the transmission of light, which processing is not needed according to the method of the present invention.

According to the method of Wang et al., one side of the sensor is

oriented in the direction of the adsorbed detection target substance, while the other side of the sensor is oriented in the light inputting-emitting direction. In this respect, the structure of the sensor element and the detection method using the sensor of Wang et al. are clearly different from those of the present invention as explicitly recited in the amended claims 15 and 23 in the present application such that, "providing light inputting means and light emitting means on one face of the sensor on which a detection target substance is adsorbed." or "light inputting means and light emitting means are provided on one face of said sensor on which a detection target substance is adsorbed."

Wang et al. discloses that the adsorption member of a substance to be measured is provided on one side of the sensor, yet Wang's idea does not extend to the one that the light inputting means and light emitting means are provided on the one face of the sensor. Therefore, Wang et al. has a structure that requires the light to be inputted and emitted on the other side of the sensor. If the ATR coupler (prism), as is required for the system, is also included, then it would be totally impossible to make the sensor and the detector slim and compact. According to the present invention, the waveguide layer is provided on QCM substrate or the crystal substrate itself is allowed to serve as the waveguide layer, and hence, it is possible to make the sensor member extremely compact through the conventional device to input light at the end face of the waveguide using an optical fiber (as proposed by the above-mentioned "butt-coupling method").

Also, whilst the method of Wang et al. is limited to the combined method of QCM and SPR, the method of the present application can utilize not only SPR (second embodiment) but also optical waveguide spectrometry (patent literature 2, first embodiment). Therefore, according to the present application, it is not necessary to use any metal for exciting a surface plasmon as the electrode of the crystal oscillator, and a transparent electrode such as ITO may be used. In the meantime, the above-mentioned "the optical waveguide spectrometry" is the one to utilize such phenomenon that an evanescent wave generated in a core is absorbed by an adsorption substance.

Further, according to the method of Wang et al., as the light undergoes total internal reflection at the interface between the QCM crystal and the medium to be measured to excite the surface plasmon, SPR measurement is impossible when the refractive index (the dielectric constant) of the medium to be measured is larger than that of the crystal, as the light does not undergo total internal reflection in that case. According to the method of the present application, however, it is possible to increase the measurable mediums by employing a material having a high refractive index for the core of the waveguide fabricated on QCM. (e.g. the refractive index of QCM crystal is approximately 1.54 to 1.55, while the refractive index of polyvinyl carbazole is approximately 1.7). Furthermore, it is also easy to be made in multi-channelled form by fabricating the waveguide in parallel.

Furthermore, Wang et al. is totally silent with the use of a local plasmon by means of a metallic colloid. "The local plasmon" (see, e.g. the third embodiment of the present invention and, reference literature "Sensors and Actuators B", 89 (2003) 126-130) is based on resonant oscillation of free electrons of metallic particles (colloids) relative to the electric-field of irradiated light, under such condition that the metallic particles exist decentrally (i.e., the metals being not connected continuously), This resonance can be utilized as the adsorption measurement because of dependence on the refractive index and thickness of the medium in the vicinity of the metallic colloid. Specifically, optical change is measured because of light absorption occurring when resonating. The teaching by Wang et al. does not involve the idea to form the metallic colloid film to utilize the local plasmon, since Wang et al. assumes the thickness of the metallic film to be the one to form the successive film (see Wang, paragraph 0127; "45 nm"). According to the present invention, however, it is positively proposed to form the metallic colloid film and to provide it on QCM substrate. Then, a light absorption by the local plasmon can be measured by employing transmission method using the transparent electrode such as ITO.

Furthermore, the Examiner asserts that "one of said electrodes is an

optical waveguide electrode made of an electrically conductive transparent material (see the Office Action, lines 11 to 13 of page 3)", "an interior of said crystal oscillator serves as an optical waveguide path (see the Office Action, lines 16 to 17 of page 3)" and "light guided through an interior of said surface acoustic wave element (see the Office Action, lines 2 to 3 of page 5)". According to the method of Wang et al., these are merely present as "an optical path" and do not function as "an optical waveguide". In the case of the optical waveguide, light propagates through the core region by a repetitive total internal reflection of the light at the interface between the core region and the cladding region. In contrast, the electrode and crystal of the method of Wang et al. do not have any particular "light-confining" effect and, as referred to as "pass through" and "pass back through" in paragraph 0094, light merely passes through. According to the method of the present invention, the optical waveguide is combined with QCM element and performs the measurement by the optical waveguide spectrometry and the surface plasmon spectrometry, increasing sensitively, utilizing multiple reflections within the optical waveguide. Therefore, the method of the present invention is totally different from Wang et al.

Referring to Kuroda et al., this document discloses that an optical fiber corresponding to the optical waveguide has "the structure of a known optical probe where the core 1401 and the cladding 1402 are coaxially arranged" (see Kuroda et al., lines 5 to 7 of the third column). It should be noted, however, that the optical fibers disclosed there have the cores wholly covered with the claddings except the front ends thereof, and are totally different from the structure of the present invention that allows the core to be exposed in the adsorption direction of a substance to be measured to thereby detect adsorption of the substance (see the first embodiment of the present invention). Furthermore, the optical fiber of Kuroda et al. is provided for "a near-field optical probe to be suitably used for a microscope capable of observing micro-structures below the diffraction limit of light, a storage device capable of forming and detecting micro recording bits or a micro-fabrication apparatus

capable of producing micro-structures" (see Kuroda et al., lines 16 to 21 of the first column), and not provided for the purpose of detecting adsorption of the substance as proposed in the present invention. Therefore, as Kuroda et al. does not teach or suggest anything about the unique direction of adsorption of a substance to be measured nor the unique light inputting-emitting direction relative to the sensor element, it is strongly believed that it would have been totally impossible for a person skilled in the art to have arrived at the present invention, even after any application of the structure of the optical fiber disclosed in Kuroda to the optical waveguide 28" as disclosed in Wang et al.

Moreover, as QCM is normally used in such a manner as to form an extremely thin film on its electrode in order to detect a substance to be measured, it is believed that it would have been difficult for a person skilled in the art to have arrived at the concept as proposed by the present invention to form the optical waveguide layer (e.g. thickness of 10 microns or more) on QCM.

Further, for the amended claims 31 and 32, it is noted that Wang et al. discloses that "the upper surface of the sensing disk is coated with a thin metal layer 19 (e.g. gold)." Applicant, however, does not consider that this corresponds to "the adsorbed-substance detecting thin film 7" in the present invention. Because "the thin metal layer" of Wang et al. is to provide the conductive surface layer in which surface plasmons are excited, while "the adsorbed-substance detecting thin firm" in the present invention is to change the refractive index after adsorption and change the outgoing light from the light emitting means. Therefore, merely applying "the thin metal layer" as disclosed in Kuroda et al. cannot achieve the effect of effectively changing the light from the light emitting means through the refractive index of the thin film being changed as proposed in the present invention. Thus, claims 31 and 32 have been amended in order to clarify this feature of the present invention.

CONCLUSION

In view of the amendment and remarks, reconsideration of the application is respectfully requested. Claims 15-32 are now pending and a Notice of Allowance for these claims is earnestly solicited.

Respectfully submitted,

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